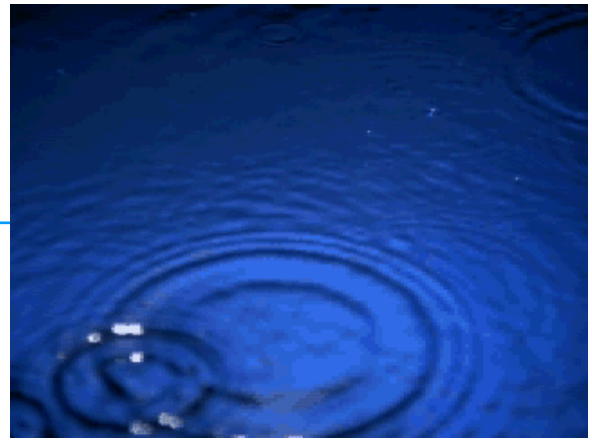
Global Precipitation Measurement

System Requirements Review
Mission (Level 2) Requirements



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Outline

- ***Overview***
- ***Science Requirements***
- ***Mission-level Requirements***
- ***Element Requirements***
  - *Primary (Core) Spacecraft*
  - *Constellation Spacecraft*
  - *Mission Operations System*
  - *Precipitation Processing System*
  - *Ground Validation System*

Level 1 Requirements

Mission:	Instrument:
* Measurement * Validation * Products * Duration	* Space Based * Ground Based
* Launch *Operations *Science Data System *Science Products * Descope * Public Outreach	

Discussed Earlier

Other Sources

* Formulation Study Results
* Science Workshops
* GSFC Guidelines

Level 2 Requirements

Science:	Mission:
* Storm Types * Precip Types * Measurements * Coverage * Frequency & Accuracy	* Data Handling * Payloads * Constellation Design * Calibration & Verification * Outreach
* Launch Services	* Process Requirements
Space Segment: * Instruments - DPR - GMI - Opportunity * Primary Spacecraft - Performance - Accommodation * Constellation Spacecraft - Performance - Accommodation	**Ground Segment:** * NASA Mission Operations - S/C Flight Ops - Space/ Ground Coordination * Ground Validation & Calibration - Super Site - Regional Rain Gauge Network * Precipitation Processing System - Product Development - Data Distribution

Key Requirements To be Discussed Now
Complete L2 Document Available For Review

Science Requirements

	Instantaneous			Daily Accumulation			Monthly Accumulation			Outreach Applications		
Measurement Factor	**Atmos**	**Hydro/ Ecol**	**Ocean**	**Atmos**	**Hydro/ Ecol**	**Ocean**	**Atmos**	**Hydro/ Ecol**	**Ocean**	**Atmos**	**Hydro/ Ecol**	**Ocean**
Dynamic Range (mm/hr)	ii, iii 0.3 to 110	iii 0.3 to 65	NA	--	--	0 to 30 mm/dy	---	---	--	NA	NA	NA
Sampling Period (hrs)	NA	NA	NA	≤ 3	≤ 3	≤ 6	≤ 3	≤ 3	≤ 6	NA	NA	NA
Spatial Resolution (km)	≤ 10	≤ 10	≤ 50	≤ 10	≤ 10	≤ 50	≤ 50	≤ 50	≤ 100	NA	NA	NA
Vertical Res of Radar (km)	≤ 0.5	NA	NA	0.5	NA-	NA-	1	NA-	NA	NA	NA	NA
iv Meas Accuracy or Bias (%)	5	5	5	5	5	5	5	5	5	NA	NA	NA
Meas Precision or Random Error (%)	25	50	50	15	20	40	10	15	20	NA	NA	NA
Snow Detection	yes	yes	no	yes	yes	no	yes	yes	no	NA	NA	NA
Snowfall Rate and/or Snow Accumulation	no ?-	no ?-	no-	no ?	yes	no	yes	yes	no	NA	NA	NA
Min Latitudinal Extent of Core (deg)	65	65	65	---	---	---	---	---	---	NA	NA	NA
Min Latitudinal Extent of Const (deg)	90	90	75	---	---	---	---	---	---	NA	NA	NA
v Data Latency	~3 hrs	~3 hrs	~1 day	~3 hrs	~3 hrs	~1 day	≤ 3 mo	≤ 3 mo	≤ 3 mo	≤ 30 min	≤ 30 min	NA

Footnotes

i This measurement requirements table will undergo refinements out through GPM Mission Confirmation Review (MCR) in March 2003. There will be four distinct versions with deadlines of December-2000 for Version 0 (preliminary estimates), August-2001 for Ve

ii Factors in red are considered underlying drivers for GPM science.

iii Specification of 0.3 mm hr-1 for required lower end dynamic range needs further study before being considered as valid preliminary estimate.

iv Specification of 5% as accuracy requirement depends upon radar measurement being sensitive to DSD variations (thus requiring 2-frequency radar), and 0.3 mm hr-1 lower end for measurement dynamic range (thus requiring radar sensitivity greater than that

v Data latency greater that 45 minutes will seriously undermine GPM's proposed outreach and applications program.

Science Requirements

- ***Discrimination of Storm Type*** ***[3.1]***
  - *Needed by weather and climate models, and for determination of latent heating*
- ***Determination of Precipitation Type*** ***[3.2]***
  - *Needed for validation of models*
- ***Measurement of Precipitation Over Land*** ***[3.3]***
  - *Input for weather and climate models*
- ***Detection of Snow*** ***[3.4]***
  - *A new capability to obtain source data for new research*
- ***Geographical Footprint*** ***[3.5]***
  - *Defines grid as 500 x 500 km for sampling*
  - *Impacts accuracy and products*
- ***Sampling Frequency*** ***[3.6]***
  - *Defines revisit to avoid diurnal aliasing – every 3 hours TBD % of the time*
  - *Drives constellation*
- ***Sampling Accuracy*** ***[3.7]***
  - *Defines data quality: 5% bias, 25% precision*
  - *Drives Validation effort*

Mission Requirements

- ***System-wide Requirements*** ***[4.0]***
  - *Data File Size: 1 minute; Many elements affected, traded latency & efficiency*
  - *Communication Protocol: Internet Protocol*
  - *Software IV&V – software must comply with 8730.4*
  - *Data links – defines all the uplink and downlink rates and modulations for the spacecraft*
- ***Payloads*** ***[5.1]***
  - *Dual Frequency Precipitation Radar* — *Needed for DSD*
  - *GPM Microwave Imager* — *Needed for sampling, transfer standard*
  - *Auxiliary Instruments* — *Provides additional opportunity*
- ***Constellation Design*** ***[5.2]***
  - *Constellation Make-up* — *Deals with shared s/c and partnerships*
  - *Spacecraft Selection* — *Guidance for filling gaps in global coverage*
- ***Calibration and Verification*** ***[6.1]***
  - *Transfer Standard from primary spacecraft to constellation*
  - *Ground Validation critical for error characterization*
- ***Products*** ***[6.2]***
  - *GPM data products* — *More detail on the products defined by L1R*

Requirement Allocation to Elements

Space Segment [5.0]

- ***Instruments: [5.1]***
  - *DPR, GMI, Opportunity*
  - *Lifetime, Operating Bands, Resolution, Scan/Swath, Physical Allocations*
- ***Spacecraft: [5.3,5.4]***
  - *Primary, NASA Constellation*
  - *Lifetime, LV I/F, Orbit, Performance, Payload Acc, Auto Ops*

Ground Segment [6.0]

- ***Mission Operations System: [6.3]***
  - *Spacecraft Operations, Data Capture, Command Generation*
  - *Element I/F & Coordination*
- ***Precipitation Processing System: [6.2]***
  - *Measurement Synthesis, Product Generation, Cal/Val*
  - *Data Processing & Distribution*
- ***Ground Validation System : [6.1]***
  - *Site Location, Instrument Complement, Output Data*

Launch Segment [7.0]

GMI Requirements

The following are the GMI Level 2 Requirements:

5.1.2 GPM Microwave Imager

5.1.2.1 GMI Lifetime

5.1.2.2 Reliability

5.1.2.3 GMI Mass Allocation

5.1.2.4 GMI Power Allocation

5.1.2.5 GMI Volume Allocation

5.1.2.6 GMI Data Allocation

5.1.2.7 GMI Earth Incidence Angle – 52.8 degrees (same as TRMM); impacts coverage

5.1.2.8 GMI Contiguous Coverage

5.1.2.9 GMI Resolution

5.1.2.10 GMI Swath Width

5.1.2.11 GMI Observing Channels

Primary Spacecraft Requirements

- ***Lifetime – 3 years with 5 year goal*** ***[5.3.1]***
  - *Satisfies L1R*
- ***Probability of Returning Instrument Data – DPR, GMI*** ***[5.3.2,-3,-4]***
  - *Provides a means to evaluate reliability design decisions*
- ***Geolocation of Measurements – DPR, GMI*** ***[5.3.6,-7]***
  - *Needed to relate measurements to models and co-observations*
- ***Orbits – Launch, Operational, Autonomous Maintenance*** ***[5.3.8,-9]***
  - *Defines orbits to satisfy coverage and mission life*
- ***Launch Vehicle Capability*** ***[5.3.10]***
  - *Defines mass to orbit*
- ***Instrument Accommodation*** ***[5.3.14]***
  - *Defines technical resources needed by the payload*
- ***Attitude Control & Knowledge*** ***[5.3.5,-6,-7,-12]***
  - *Needed to support geolocation and co-observations*
- ***Communications*** ***[5.3.15]***
  - *Defines uplink, downlink, data allocations*
- ***Use GPS*** ***[5.3.11]***
  - *DPR needs to calculate range bins, thus reducing the data rate*

Constellation Spacecraft Requirements

- ***Lifetime – 3 years with 5 year goal*** ***[5.4.1]***
  - *Satisfies L1R*
- ***Probability of Returning Instrument Data – GMI [5.4.2]***
  - *Provides a means to evaluate reliability design decisions*
- ***Geolocation of Measurements – GMI*** ***[5.4.4]***
  - *Needed to relate measurements to models and co-observations*
- ***Orbits –Operational*** ***[5.4.3]***
  - *Defines orbits to satisfy coverage and mission life*
- ***Instrument Accommodation*** ***[5.4.10]***
  - *Defines technical resources needed by the payload*
- ***Attitude Control & Knowledge*** ***[5.4.5,-6]***
  - *Needed to support geolocation and co-observations*
- ***Communications*** ***[5.4.11]***
  - *Defines uplink, downlink, data allocations*
- ***Use GPS*** ***[5.4.8]***

Mission Operations Requirements

- ***Mission Operations:*** ***[6.3.1]***
  - *Health & Safety* — *Standard capability*
  - *Availability* — *Ensures ops center is up for critical operations*
  - *CMD & TLM* — *Standard capability*
  - *Data Handling and Interfaces* — *ops co-ordinates all of the assets*
  - *Flight Software Maintenance* — *Standard capability*
- ***Instrument Operations:*** ***[6.3.2]***
  - *Commanding*
  - *Performance Monitoring*
- ***Space/Ground Link:*** ***[6.3.3,-4]***
  - *Data Loss Allocations*
  - *Contingency Operations* — *Switch to ground if TDRSS is lost*

Precipitation Processing System Requirements

- ***Precipitation Measurement Synthesis [6.2.1]***
  - *Used for the calibration transfer standard between primary and constellation s/c*
- ***Product Definition [6.2.2,-3,-4]***
  - *This is the output of the GPM mission*
- ***Open Architecture [6.2.5]***
  - *Provides the ability to make incremental improvements*
- ***Processing Capacity [6.2.6]***
  - *Makes sure the system is big enough to do the job*
- ***Instrument Data Handling [6.2.7]***
  - *Defines the handling of raw data into and within the PPS*
- ***Ground Validation [6.2.8]***
  - *Coordinate overpass and co-observations*
- ***Data Processing Operations [6.2.9]***
  - *Handle all the data within the latency requirements*
- ***Data Archiving and Distribution [6.2.10]***
  - *Makes sure the proper people have their data in a timely manner*

Ground Validation Requirements

General—fundamental purpose of GV

- *Error Characterization [6.1.1]*
- *Error Diagnosis [6.1.2]*

Supersites

- *Local Area Supersite [6.1.3]*
- *Site Location [6.1.3.5]*
- *Site Instrumentation [6.1.3.4, 6.1.3.6]*
- *Expansion Rules [6.1.3.3]*
- *Bias Reports [6.1.3.1, 6.1.3.2]*

- *Regional Rain Gauge Network [6.1.4]*